INDOOR AIR QUALITY ASSESSMENT

Lake Street School
17 Lake Street
Spencer, MA 01562

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Spencer/East Brookfield School Department and State Senator Stephen M. Brewer's office, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) conducted an indoor air quality assessment at the Lake Street School (LSS) located at 17 Lake Street, Spencer, Massachusetts. On February 17, 2006, a visit to conduct an assessment at the LSS was made by Cory Holmes, Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program.

The school is a two-story red brick building constructed in 1957. An addition was built in 1977. No renovations to the building were reported; therefore the majority of building materials (e.g., flooring, heating and ventilation components and window systems) appear to be original. The school contains general classrooms, kitchen, a multi-purpose room (cafeteria/auditorium/gymnasium), library, art room, computer rooms and office space.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 500 students in pre-school through 3rd grade with a staff of approximately 75. Tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 ppm (parts per million) in seventeen of thirty-three areas surveyed, indicating inadequate air exchange in about half of the areas tested. Fresh air in each classroom is supplied by a unit ventilator (univent) system (Pictures 1 and 2). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Adjustable louvers control the ratio of fresh outdoor air to recirculated air. Some classrooms with univents installed above the ceiling, which delivers air to classrooms via multi-directional air diffusers connected to ductwork (Picture 4).

Univents were operating in the majority of areas surveyed; however, the air intakes for classroom 16 and Mrs. Sprow's room were sealed with plastic and duct tape (Picture 3). The air intakes were reportedly sealed to prevent freezing of pipes, which had occurred several times in the past year resulting in water damage in these areas. This condition can be the result of the malfunctioning of univent airflow control louvers, which leaves the fresh air intake open during non-school hours. In order for univents to provide fresh air as designed, they must be activated while rooms are occupied and air intakes and diffusers should remain free of obstruction.

The mechanical exhaust ventilation system consists of wall-mounted vents (Pictures 5) or vents installed in the ceilings of coat closets (Picture 6). Vents are ducted to rooftop motors. Exhaust vents were deactivated during the assessment. During the assessment, the school custodian reactivated exhaust ventilation in some areas; however, exhaust ventilation in other areas was not functioning due to a faulty motor. Exhaust vents were also found obstructed by furniture, boxes and other items during the assessment (Picture 5). In order for exhaust vents to function as designed, they must be activated and free of obstructions. Without functioning exhaust ventilation, odors and other environmental pollutants can build up due to lack of air exchange. It is also important to note that the location of some exhaust vents can limit exhaust efficiency. In some classrooms, exhaust vents are located near hallway doors (Picture 7). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from the classroom.

The ground floor contains an internal room (called the “spare room”), which is reportedly used by small groups several times a week. The spare room has neither mechanical ventilation nor openable windows. Little air exchange is provided in this area, as evidenced by elevated carbon dioxide readings, which were measured at 1,649 ppm with five occupants in the room (Table 1). Consideration should be given to installing mechanical ventilation or at the least, a passive door vent to provide air exchange.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that a room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A of this assessment.

Temperature measurements ranged from 69 ^{o} F to 74 ^{o} F, which were within or very close to the MDPH recommended comfort range in all areas surveyed during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 34 to 50 percent, however most areas were within the MDPH recommended comfort range of the areas surveyed during the assessment. The MDPH recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. During the heating season, relative humidity levels would be expected to drop below the recommended comfort range. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

A characteristic staining of floor tiles associated with chronic moisture was observed in several classrooms in the 1977 wing (Pictures 8 and 9). MDPH staff examined stained floor tiles in affected classrooms and recommended that they be cleaned and disinfected as a temporary measure. School officials could not confirm whether a vapor retarder had been installed to prevent moisture seepage from sub-slab areas. Such a barrier would have been installed when the addition was constructed. Without a vapor retarder, moisture can be drawn upward through the concrete slab by hydrostatic pressure and/or capillary action. Moisture can dissolve alkalis in concrete to form a solution that can raise pH levels beneath flooring, which leads to the breakdown of adhesives (Donnelly, 2005). Another potential source of moisture was observed outside the building in this area. Water pooling was observed directly outside classroom 27 (Picture 10), which had the most prominently stained floor tiles. A breach was observed between the brick and concrete foundation in the area, which can serve as a pathway for moisture beneath tiles (Picture 11).

Several areas had water damaged ceiling tiles (Picture 12), which can indicate leaks from the roof or plumbing system. Water damaged ceiling tiles and other porous building materials can provide a source for mold growth and should be replaced after a moisture source or leak is discovered and repaired.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur. Cleaning cannot adequately remove mold growth from water-damaged porous materials. The application of a mildewcide to moldy porous materials is not recommended.

Plants were noted in close proximity to univent air intakes (Picture 13) and diffusers. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

A bird's nest was observed in the exterior housing of a local exhaust vent located in the art room (Picture 14). At the time of the assessment, CEH staff recommended removing the nest and disinfecting the vent louvers with an anti-microbial agent. CEH staff also recommended sealing the vent on the inside with plastic and duct tape prior to cleaning to prevent infiltration of bacteria, mold or associated odors into the art room. Birds can be a source of disease, and bird wastes and feathers can contain mold, which can be irritating to the respiratory system. CEH staff did not observe obvious signs of a bird roosting inside the building nor were such signs reported by occupants.

Finally, exterior caulking around windows was missing/damaged in many areas (Pictures 15). Some of the panes were loose or broken and drafts were evident in several areas. Missing caulking and/or loose fitting window panes can make it difficult to control temperature and allow a means for water penetration into the building, leading to comfort complaints and/or water damage and subsequent microbial growth.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND). A slight carbon monoxide reading of 1 ppm was measured in the boiler room and in several rooms on the ground floor (Table 1). These measurable levels can be attributed to the boiler room door being propped open (Picture 16). Carbon monoxide levels in the remainder of the school were ND (Table 1).

School officials reported periodic odors during fuel delivery. The vent pipe for the fuel tank is located in close proximity to classroom windows and univent air intakes (Picture 17). Fuel delivery during school hours can result in fuel odors and/or vehicle exhaust emissions penetrating into classrooms adjacent to the oil tank through open windows and/or the mechanical ventilation system. In turn, this can provide opportunities for exposure to products of combustion, including carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 34 $\mu g/m^3$ (Table 1). PM2.5 levels measured in occupied areas of the school ranged from 19 to 49 $\mu g/m^3$ (56 in the boiler room), which were below the NAAQS of 65 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Indoor TVOC concentrations were ND (Table 1). An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. A potential source of VOCs was observed in the storage room, which is accessed through a door in the library or through a garage door on the exterior of the building (Picture 18). At the time of the assessment, a gas-powered snow blower, lawn equipment and gasoline containers were being stored inside the storeroom (Picture 19). Odors and off-gassing of VOCs from gasoline can have an adverse effect on indoor air quality. No local exhaust ventilation is installed in this area to remove odors. Several pathways were observed for VOCs and other odors (e.g., combustion emissions) to migrate into occupied areas; these included holes in walls (Picture 20) and spaces around the door to the library. Occupants reported that odors from the gas-powered equipment were periodically detected in the school.

Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were also found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 21). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 22). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause TVOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

A photocopier was observed in the second floor book room. Photocopiers can produce VOCs and ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992). Although the photocopier was located beneath a local exhaust vent (Picture 23), the vent was sealed with cardboard (Picture 24).

Several other conditions that can affect indoor air quality were noted during the assessment. In a number of classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Univent return vents, air diffusers, exhaust vents and portable air conditioning units (and their filters) had accumulated dust (Pictures 25 and 26). If exhaust vents are not operating, back drafting may occur, resulting in re-aerosolization of accumulated dust particles; univents and AC units can also aerosolize dust particles when activated. Dust can be irritating to the eyes, nose and respiratory tract.

Inactive insect nests that serve as learning props were seen in a few classrooms (Picture 27). Nests can contain bacteria and may also be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material. These items should also be located away from univent's fresh air diffusers.

Finally, environmental tobacco smoke (ETS) odors were detected in the boiler room and adjacent hallway during the assessment. Smoking in public places is prohibited under the general laws of Massachusetts M.G.L. c. 270, sec. 22. Second hand environmental tobacco smoke can be irritating to the eyes, nose, throat and respiratory system.

Conclusions/Recommendations

The general building conditions, maintenance, work hygiene practices and the condition/age of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further degrade indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required for remediation. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Contact a HVAC engineering firm to investigate and provide recommendations regarding the freezing of pipes and sealing of univent fresh air intakes in problem areas. In some cases the MDPH has recommended installation of a sheet metal awning that can direct cold air/wind away from intake vents (Picture 28).
2. Ensure univent air intakes are unsealed after the heating season to provide fresh air as designed.
3. Survey classroom univents to ascertain function and determine whether an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.

4. Operate all ventilation systems throughout the building (e.g., gym/cafeteria, classrooms) continuously during periods of school occupancy and independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to "high".
5. Continue with plans to replace exhaust motor on repair list. Inspect rooftop exhaust motors and belts periodically for proper function, repair and replace as necessary.
6. Remove all blockages from univents and exhaust vents. Remove cardboard from exhaust vent in 2nd floor book room and restore local exhaust ventilation above photocopier.
7. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
8. Consider discontinuing use of the spare room as classroom space. If not feasible, make provisions to install mechanical ventilation to provide air exchange.
9. Close classroom doors to maximize air exchange.
10. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters.

Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

12. Contact a masonry firm or general contractor to repair breaches in exterior wall outside classroom 27 to prevent water penetration, drafts and pest entry.

13. Consider removing floor tiles in areas of chronic water damage (e.g., classroom 27) to determine if visible moisture and/or microbial growth are present. If so, the removal of all affected tiles followed by cleaning with an appropriate antimicrobial agent may be necessary.

14. Consider contacting a reputable flooring contractor to remove/replace old tiles and mastic. Slab should be completely cleaned and sealed with a proper sealant and/or vapor barrier.

15. Consider contacting a building engineer for an examination of possible moisture remediation/prevention strategies if moisture accumulation/damage to floor tiles in the building recurs.

16. Ensure bird's nest is removed from art room exhaust vent (Picture 14). Inspect to ensure surfaces are free of nesting materials and bird wastes. Clean and disinfect with an appropriate antimicrobial where necessary. Consider installing wire mesh or seal permanently to prevent further roosting.

17. Ensure any roof/plumbing leaks are repaired. Replace water-damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

18. Repair/replace broken windows; re-seal loose window frames to prevent drafts and water penetration.

19. Move plants away from univents in classrooms and away from air intakes on the exterior of the building (Picture 13). Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.

20. Consider storing gas powered snow/lawn equipment and fuel containers in a location outside the building (e.g., storage shed). If not feasible, consult with local fire officials to determine compliance with local/state fire codes

21. Seal utility holes/breaches in walls in storeroom to prevent the migration of fuel and/or combustion odors.

22. Consider sealing access door to storeroom in library. If not feasible install weather stripping/door sweeps around exterior doors to prevent, drafts and odor migration. Ensure tightness of doors by monitoring for light penetration and drafts around doorframes.

23. Store cleaning products properly and out of reach of students.

24. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.

25. Clean univent air diffusers/return vents, portable air conditioners and exhaust vents periodically of accumulated dust to prevent the accumulation/aerosolization of dirt, dust and particulates.

26. Consider removing carpet or clean annually (or semi-annually in soiled high traffic areas) as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC). Copies of the IICRC fact sheet can be downloaded at: http://www.cleancareseminars.com/carpet_cleaning_faq4.htm (IICRC, 2005)

27. Continue with plans to raise fuel tank vent pipe above the roof. Schedule oil deliveries after school or when school is not occupied. If not feasible, notify school staff including those whose classrooms are in close proximity to oil tank, in advance of scheduled delivery so occupants can take precautions (e.g., deactivate univents, close windows). This should reduce/eliminate fuel odors and/or vehicle exhaust entrainment into classrooms.

28. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner that allows for a timely remediation of the problem. An example is included as Appendix C.

29. Store nests in resealable bags to prevent aerosolization of irritants or consider bring in on an "as needed" basis.

30. Enforce antismoking policies in accordance with Massachusetts General Laws. M.G.L. c. 270, sec. 22.

31. Consider discontinuing the use of tennis balls on furniture and replacing tennis balls with alternative "glides". Refer to Picture 28 for an example.

32. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

33. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

The following **long-term** recommendations are also suggested:

1. Contact an HVAC engineering firm for a full evaluation of the ventilation system. Considering the age, physical deterioration and availability of parts of the HVAC system, an evaluation is strongly recommended for proper operation and/or repair/replacement of the ventilation system.
2. Repair and/or replace thermostats and pneumatic controls as necessary to maintain control of thermal comfort. Consider contacting an HVAC engineer concerning the condition and calibration of thermostats and pneumatic controls school-wide.
3. Consider having a full building envelope evaluation to determine the source moisture contributing to damaged floor tiles.
4. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.

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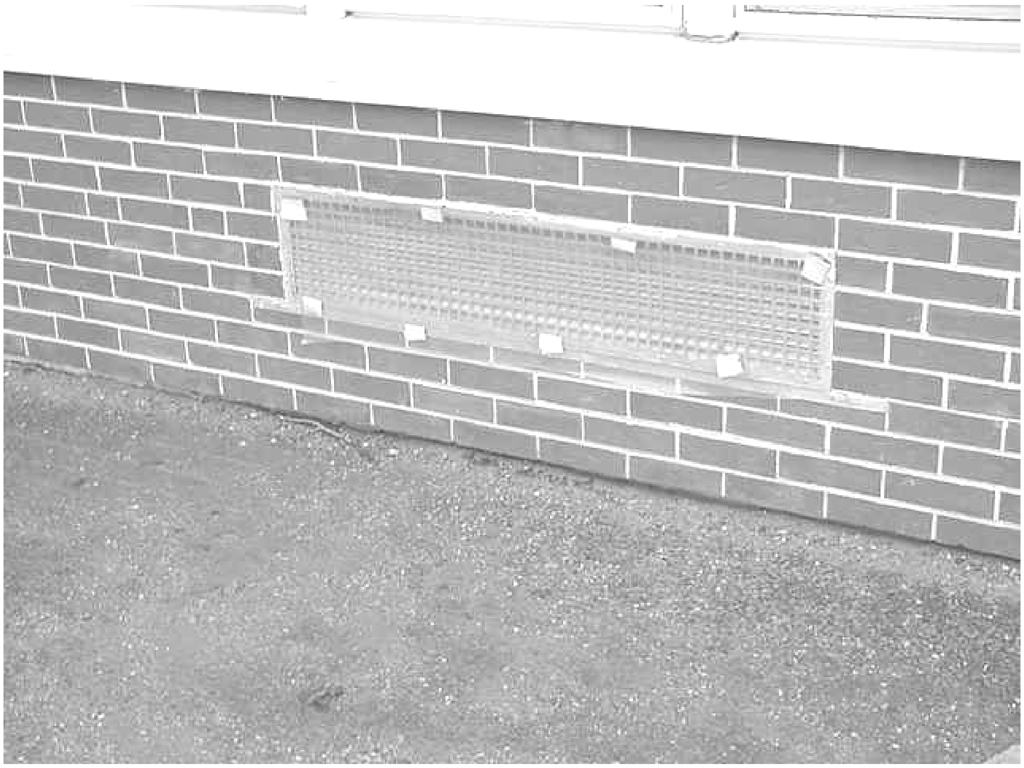
Picture 1

Classroom Univent 1950's Vintage

Picture 2

Classroom Univent 1970's Vintage

Picture 3



Univent Air Intake, Note this Intake was Sealed with Plastic and Duct Tape to Prevent Freezing of Pipes

Picture 4

Ceiling-Mounted Supply Vents

Picture 5

Wall-Mounted Exhaust Vent (1950's Wing) Obstructed by File Cabinet

Picture 6

Coat Closet Exhaust Vent in 1970's Wing

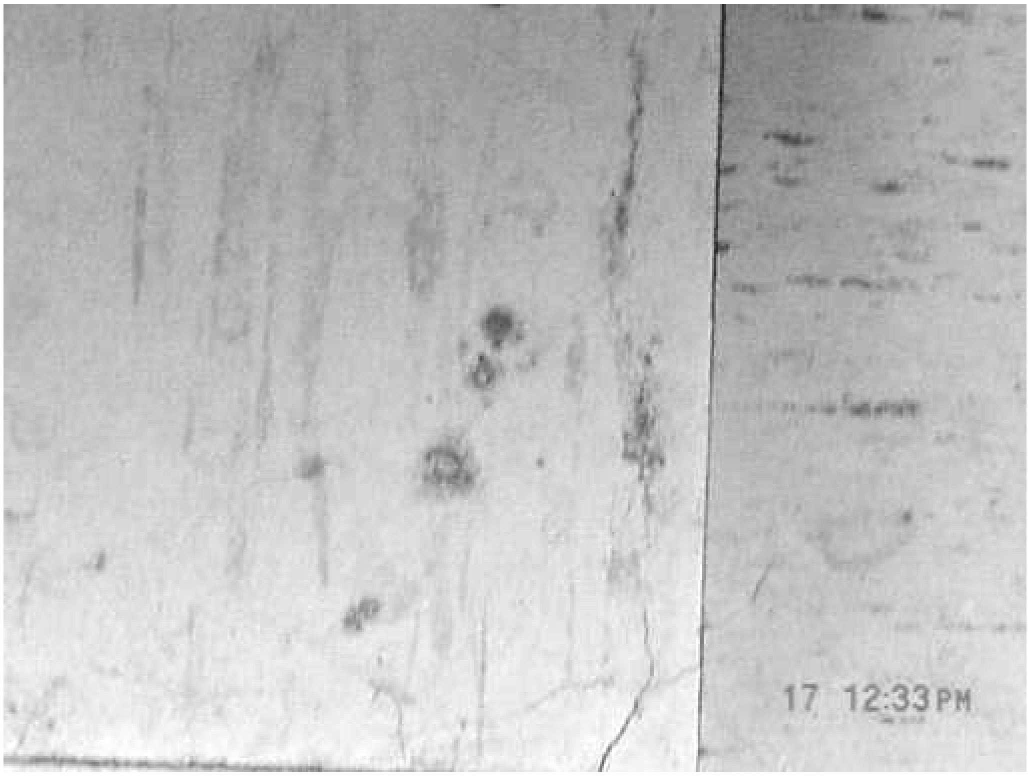
Picture 7

Wall-Mounted Exhaust Vent (1950's Wing) behind Open Hallway Door

Picture 8

Staining of Floor Tiles in Classroom 27, 1970's Wing

Picture 9

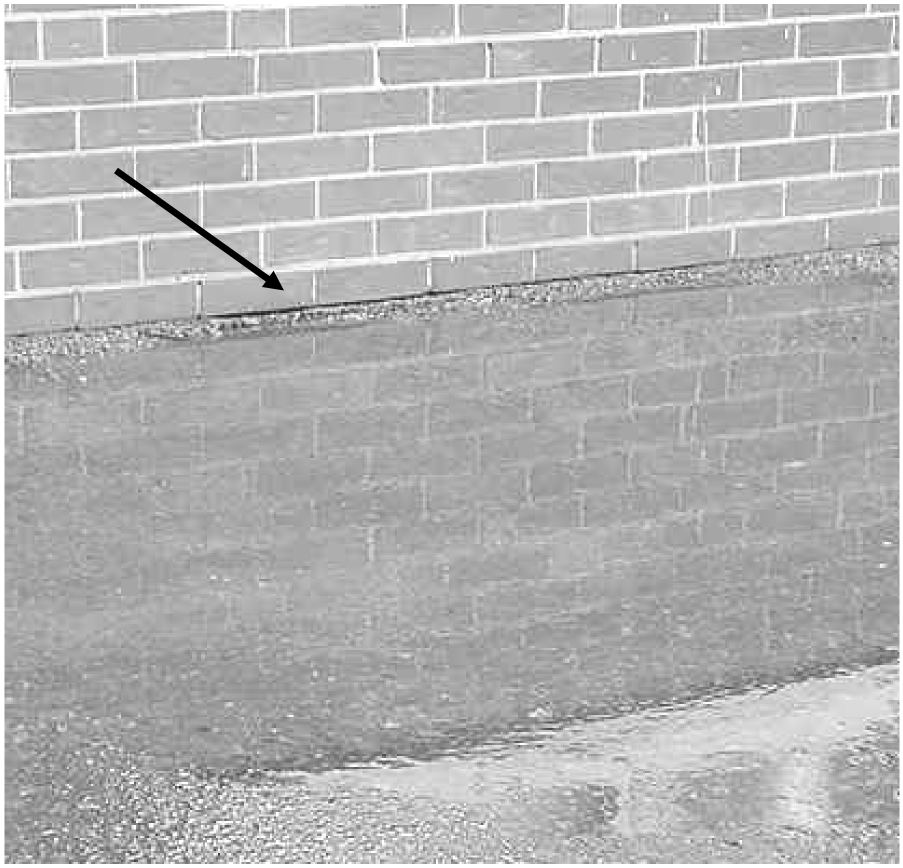


Staining of Floor Tiles in Classroom 27, 1970's Wing

Picture 10

Water Pooling outside of Classroom 27, 1970's Wing

Picture 11



Breach between Brick and Foundation in Area of Water Pooling Outside Classroom 27

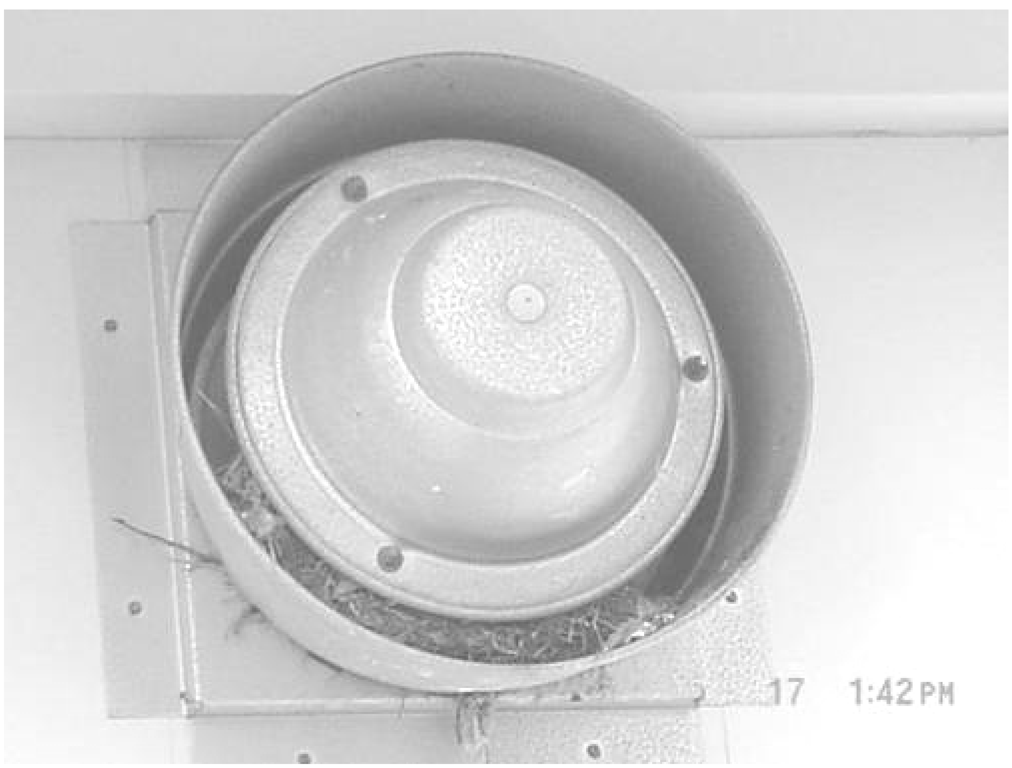
Picture 12

Water Damaged Ceiling Tiles

Picture 13

Shrubbery in Close Proximity to Univent Air Intake

Picture 14



Bird Nesting Materials in Local Exhaust Fan Housing (Art Room)

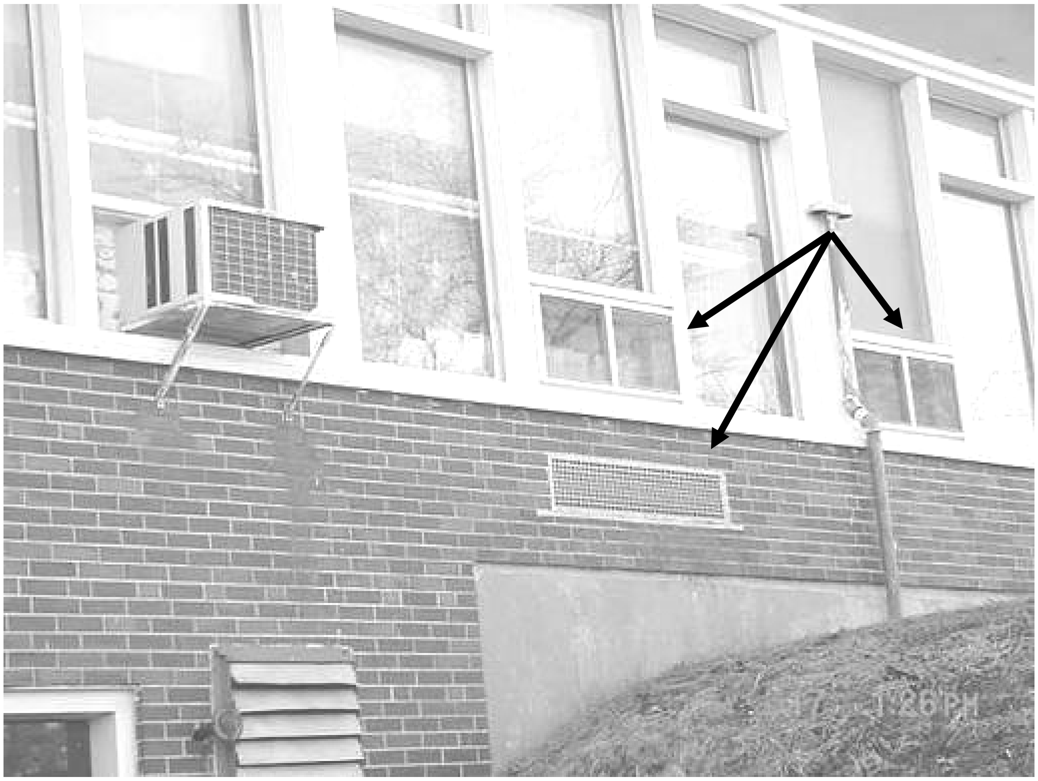
Picture 15

Damaged Exterior Caulking around Window

Picture 16

Boiler Room Door Propped Open during the Assessment

Picture 17

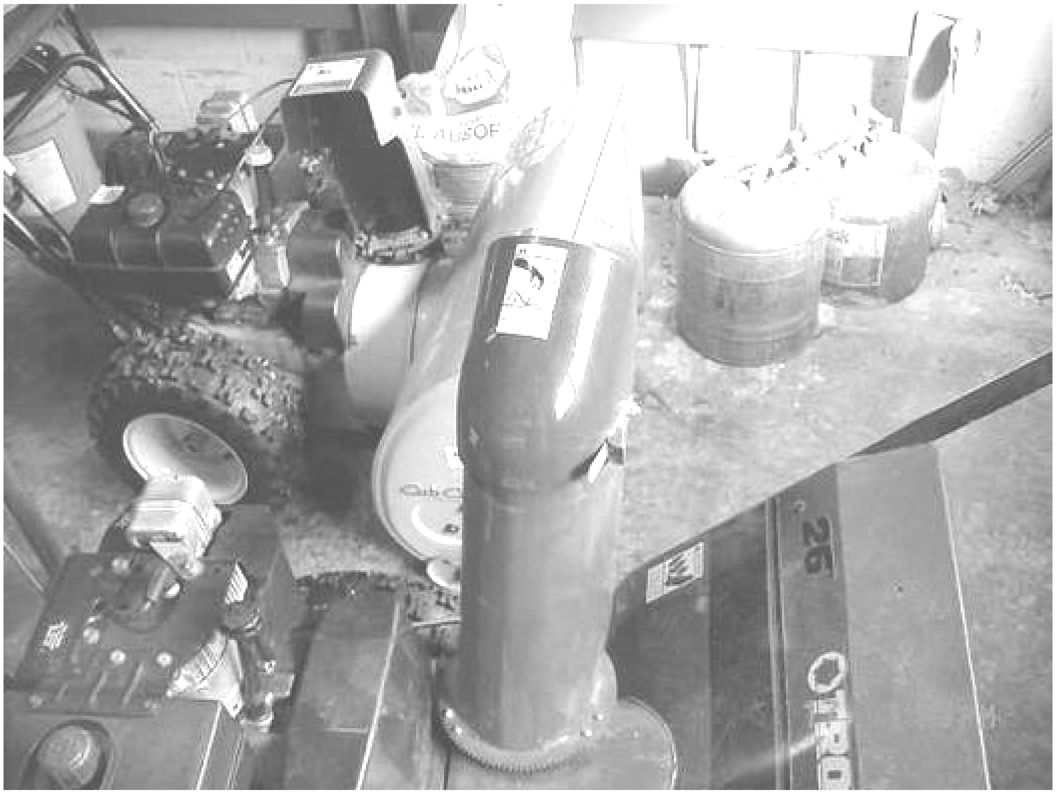


Proximity of Vent Pipe for Fuel Tank (on Right) to Classroom Windows and Univent Air Intake

Picture 18

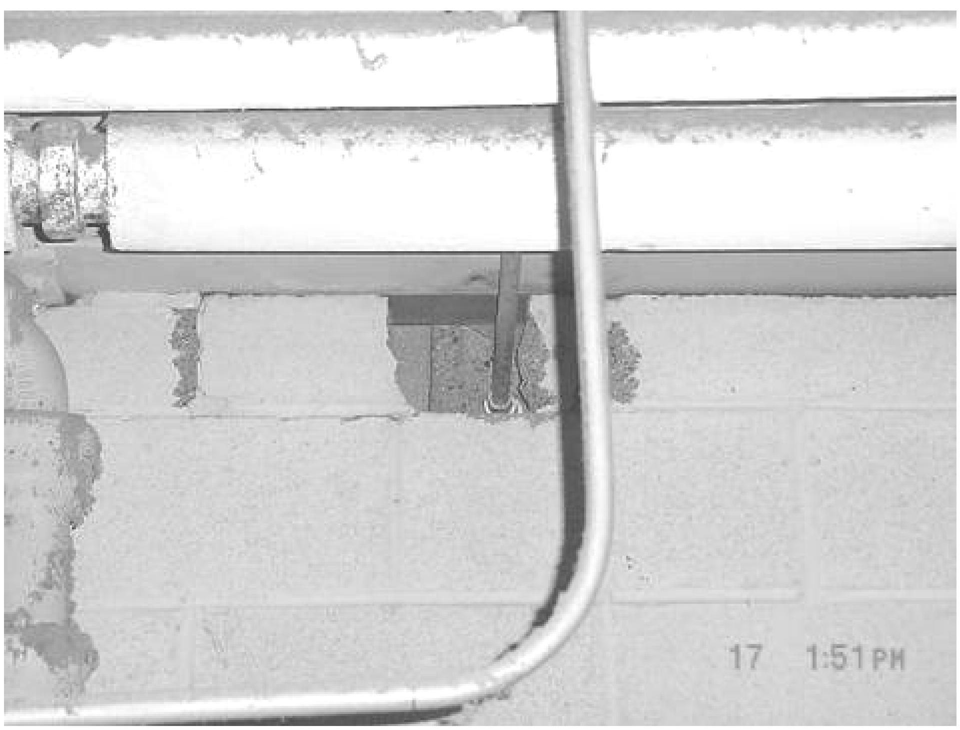
Exterior Garage Door for Storage Room

Picture 19



Snow Removal Equipment and Gasoline Cans in Store Room

Picture 20



Large Utility Hole in Wall Separating the Library and Storage Room that Contains, the Snow Blower, Lawn Equipment and Gasoline Containers

Picture 21

Spray Cleaning Products in Unlocked Cabinet under Classroom Sink

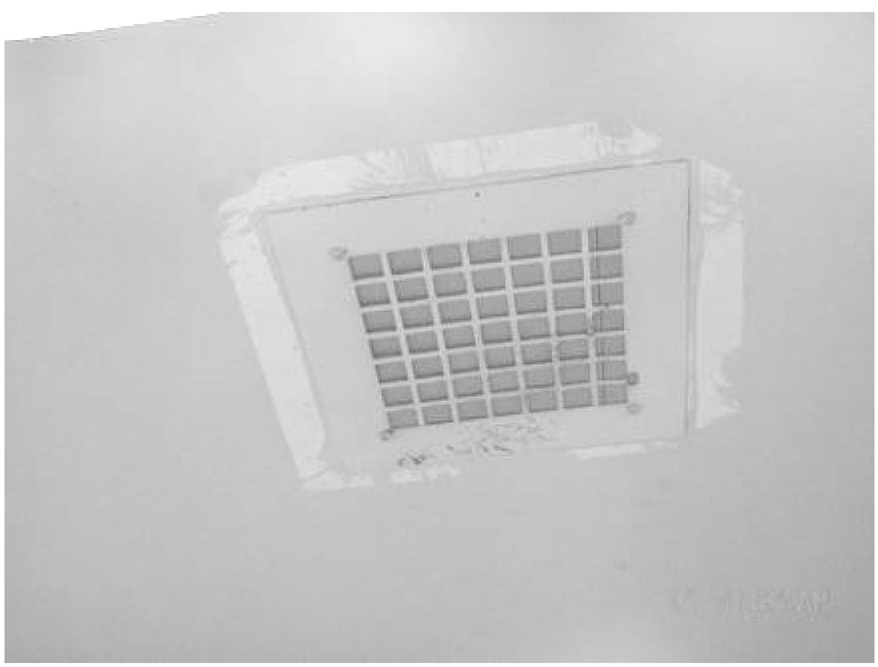
Picture 22

Tennis Balls on the Bottom of Chair Legs in Classroom

Picture 23

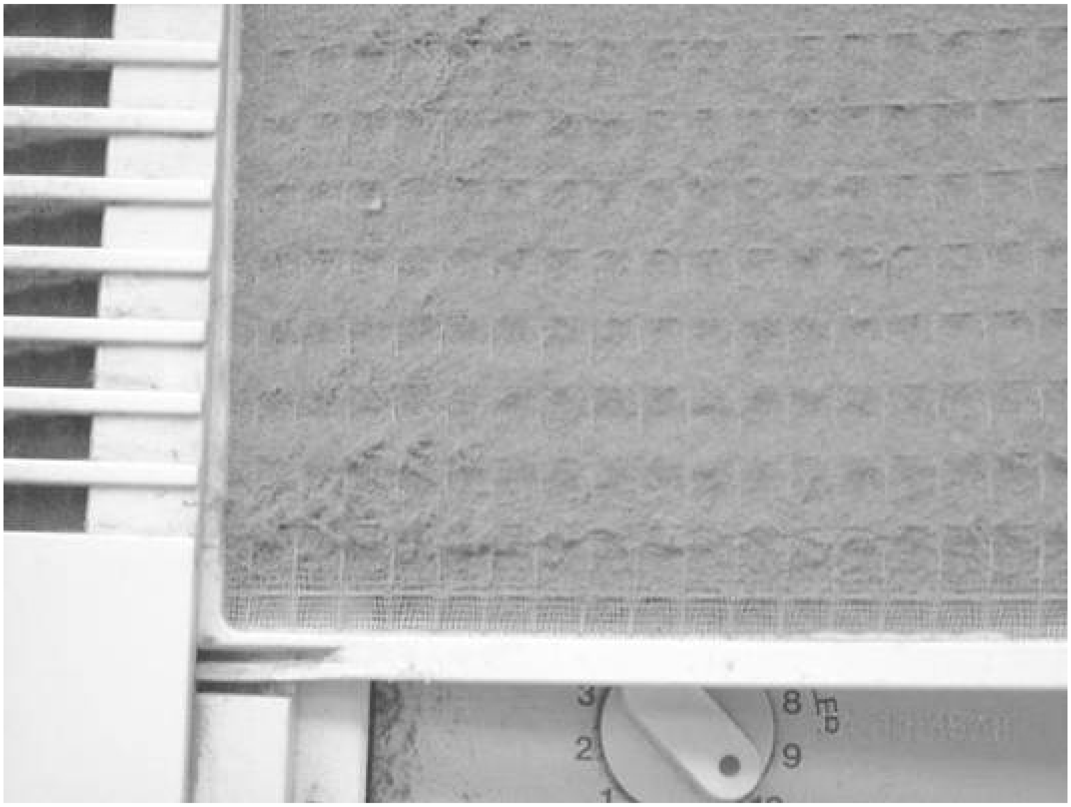
Photocopier beneath Local Exhaust Vent, in 2nd Floor Book Room

Picture 24



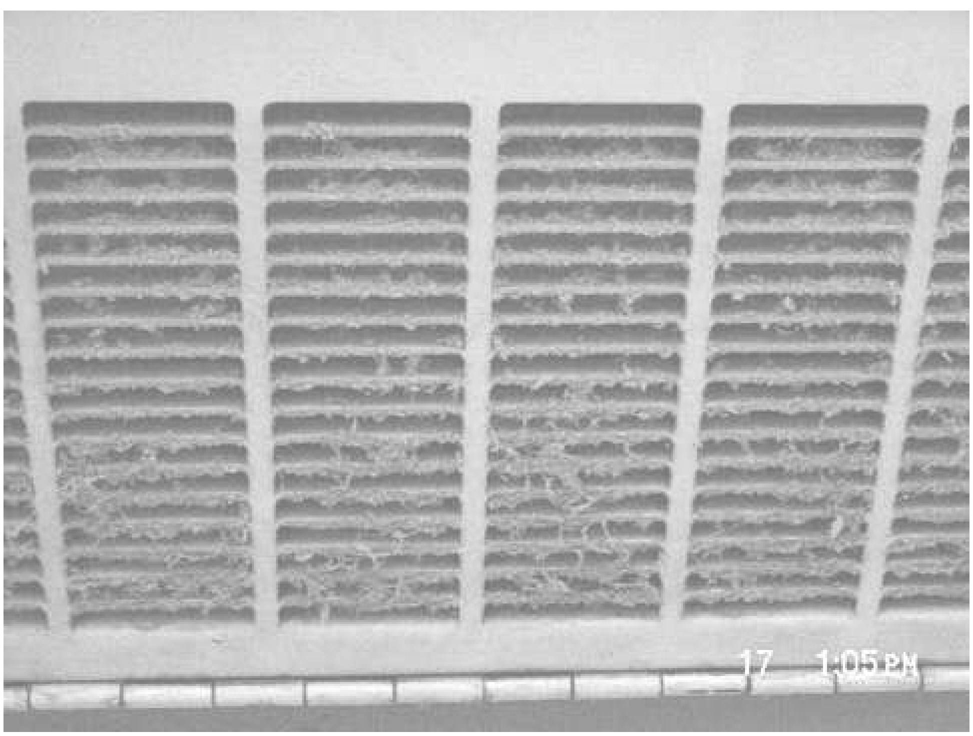
Close-up of Local Exhaust Vent Sealed with Cardboard, in 2nd Floor Bookroom

Picture 25



Dust Accumulation on Filter for Classroom Air Conditioning Unit

Picture 26

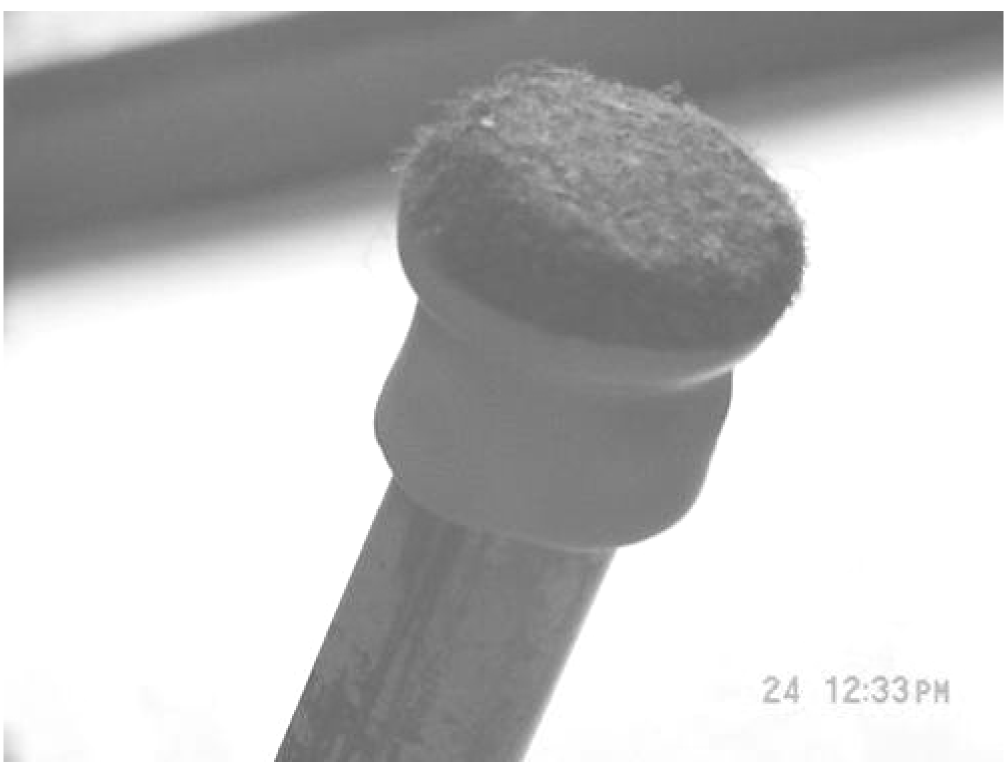


Univent Return Vent

Picture 27

Fresh Air Intake Awning/Shield Recommended For Installation over Fresh Air Intakes
(Picture Taken at King Phillip Regional High School, Wrentham, MA)

Picture 28



"Glides" for Chair Legs that can be used as an Alternative to Tennis Balls

Lake Street School | **Indoor Air Results**

17 Lake Street, Spencer, MA 01562 | **Date: 2/17/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	54	89	328	ND	ND	34	N			rainy, winds WSW 20-40mph, heavy clouds.
art room	18	73	35	649	1	ND	21	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, TB, plants, local exhaust vent-birds nest.
boiler room	1	70	39	542	1	ND	56	N			Hallway DO, smoke odors.
cafeteria	6	74	38	811	ND	ND	32	N	Y ceiling	Y ceiling	100 occupants gone 5 min.
library	43	72	36	898	1	ND	19	Y # open: 1 # total: 7	Y univent dust/debris	Y wall	Hallway DO, plants, utility holes/spaces around garage door.
Ms. Sprow's room	9	73	38	670	1	ND	39	N	Y univent (off) dust/debris	Y ceiling wall (off)	sealed, WD-carpet.
nurse	8	71	35	601	ND	ND	22	Y # open: 2 # total: 3	N	N	Hallway DO,

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Lake Street School | **Indoor Air Results**

17 Lake Street, Spencer, MA 01562 | **Date: 2/17/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
spare room	5	74	39	1649	1	ND	40	N	N	N	recommend passive vent in door (supply).
speech	0	71	42	838	ND	ND	36	Y # open: 0 # total: 3	N	Y wall	Hallway DO, DEM.
Title 1	3	71	44	952	ND	ND	31	Y # open: 0 # total: 3	N	Y wall	items.
1	22	70	42	675	ND	ND	38	Y # open: 0 # total: 4	Y univent	Y wall	local AC, DEM, TB.
2nd floor book room	0	72	41	773	ND	ND	27	N	Y	Y ceiling (off)	Hallway DO, sealed, PC.
2	23	72	42	881	ND	ND	44	Y # open: 2 # total: 3	Y univent	Y wall items furniture	Hallway DO, PF, TB.
3	20	72	42	677	ND	ND	35	Y # open: 1 # total: 3	Y univent	Y wall	Hallway DO, local AC, DEM, dusty AC grill/filter.

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Lake Street School **Indoor Air Results**

17 Lake Street, Spencer, MA 01562 **Date: 2/17/2006**

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									Supply	Exhaust	
4	20	73	42	1160	ND	ND	31	Y # open: 0 # total: 4	Y univent	Y wall	
5	24	73	44	1022	ND	ND	46	Y # open: 0 # total: 3	Y univent	Y wall furniture	Hallway DO, local AC, DEM.
6	26	73	45	769	ND	ND	32	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, local AC, DEM, aqua/terra, plants, dusty AC grill/filter.
7	13	71	50	946	ND	ND	30	Y # open: 1 # total: 1	Y univent	Y wall furniture	local AC, CD, DEM, dusty AC grill/filter.
8	1	69	43	616	ND	ND	34	Y # open: 0 # total: 5	Y univent	Y wall (off)	Hallway DO, AP, TB.
10	0	70	40	417	ND	ND	20	Y # open: 0 # total: 5	Y univent furniture	Y wall items furniture	Hallway DO,

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Lake Street School **Indoor Air Results**

17 Lake Street, Spencer, MA 01562 **Table 1** **Date: 2/17/2006**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
11	21	72	45	954	ND	ND	32	Y # open: 0 # total: 5	Y univent	Y wall (off)	
12	0	71	42	673	ND	ND	38	Y # open: 0 # total: 7	Y univent	Y wall furniture	Hallway DO, DEM, plants, 24 occupants gone 8 mins.
13	23	71	50	1108	ND	ND	35	Y # open: 0 # total: 5	Y univent	Y wall	plants.
16	3	73	34	588	1	ND	19	N	Y univent	Y	Hallway DO, sealed, WD-carpet, WD-porous material.
17	0	71	41	636	ND	ND	31	Y # open: 0 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, PF.
19	4	69	42	482	ND	ND	36	Y # open: 2 # total: 4	Y ceiling	Y ceiling	temperature complaints (hot).
20	26	73	45	1156	ND	ND	35	Y # open: 0 # total: 4	Y univent	Y closet	DEM.

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21	21	74	43	1082	ND	ND	47	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, plants.
22	23	73	42	978	ND	ND	49	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, PF, cleaners.
23	24	73	40	920	ND	ND	41	Y # open: 1 # total: 4	Y univent		Hallway DO, #WD-CT: 1, DEM, TB, broken window.
24	23	73	41	876	ND	ND	45	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, #WD-CT: 2, TB.
25	13	73	40	679	ND	ND	37	Y # open: 1 # total: 4	Y univent	Y closet	Hallway DO,
26	2	73	42	956	ND	ND	36	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, nests, plants, occupants at lunch.
27	14	71	42	737	ND	ND	37	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, WD-carpet, #WD-CT: 2, PF.

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Appendix C

BEDFORD PUBLIC SCHOOLS

TOWN OF BEDFORD

WORK ORDER

REPAIR # ________

DATE: __________ TIME: __________

- ☐ ROUTINE
- ☐ EMERGENCY
- ☐ VIOLATION
- ☐ PROJECT

REQUESTED BY: ________ ext.

APPROVED BY: ________ ext.

SCHOOL/BUILDING

MACHINE #	Room #

DESCRIPTION OF PROBLEM:

____

____

LIST BELOW ACTUAL WORK DONE:	DONE BY: DATE:	DONE BY: INITIALS	WORK TIME: HRS.	WORK TIME: MIN.

NOTES:

____

____

____

CREW ASSIGNMENTS:

- ☐ 00. MAINT. TECH.
- ☐ 01. HVAC TECH
- ☐ 02. CARPENTER
- ☐ 03. ELECTRICIAN
- ☐ 04. PLUMBER
- ☐ 05. PAINTER
- ☐ 06. CUSTODIAN
- ☐ 07. SUPERVISOR
- ☐ 08. DRIVER
- ☐ 09. SECRETARY
- ☐ 10. OTHER

CAUSE:

- ☐ 0. PM DIRECTED
- ☐ 1. PREV. MAINT.
- ☐ 2. FAILURE
- ☐ 3. VANDALISM
- ☐ 4. PROJECT
- ☐ 5. SAFETY
- ☐ 6. TRAINING
- ☐ 7. ADMINISTRATION
- ☐ 8. TOILET/ DRAIN PROB
- ☐ 9. CIRCUIT BREAKER
- ☐ A. OTHER

MATERIALS

LINE	QUANTITY	DESCRIPTION	COST
		TOTAL:	

SUPERVISION USE ONLY

WAITING FOR PARTS	SCHEDULE
PURCH. ORDER #:	START:
DATE ORDERED:	COMPLETE:
DATE RECEIVED:	REVIEWED:

White - Facilities Dept./Yellow - Return to Issuer/Pink - School or Dept. Requesting